

Relation of cigarette smoking to risk of death of asbestos-associated disease among insulation workers in the United States¹

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Data have been reported indicating that cigarette smoking greatly increases the risk of death by lung cancer among asbestos insulation workers (Selikoff *et al.*, 1968). It was calculated that asbestos insulation workers with a history of regular cigarette smoking had eight times the risk of lung cancer deaths compared with cigarette smokers who did not do such work, and approximately ninety times the risk of men who neither worked with asbestos nor smoked cigarettes.

We have obtained further evidence on this matter, bearing on aspects of asbestos-associated disease for which data were previously scant or incomplete.

LUNG CANCER AMONG CIGARETTE-SMOKING ASBESTOS INSULATION WORKERS

Recent experiences have confirmed that lung cancer among insulation workers is largely confined to those men with a history of cigarette smoking. Data are derived from observation of two cohorts of insulation workers. Since they differ in age distribution and work experience, it is advantageous to consider them separately.

First, we have followed a group of 370 insulation workers from 1 January 1963. These were survivors of 632 men who were members of locals of the insulation workers' union in the New York area on 1 January 1943 (Selikoff *et al.*, 1964). Therefore, in 1963 these men were all at least 20 years from onset

of employment (indeed, 333 had reached thirty or more years from onset) (Table 1). Two hundred and eighty-three of these men had histories of regular cigarette smoking; by 30 April 1967, 24 had died of lung cancer although, given their smoking habits, only 2.98 such deaths had been expected. No deaths from lung cancer occurred among the 87 men with no history of cigarette smoking (Selikoff *et al.*, 1968).

The cohort has now been traced for an additional 56 months. Table 2 shows findings for the nine-year period from 1 January 1963 to 31 December 1971. Of 283 men who smoked cigarettes regularly, 41 died of lung cancer; while of 87 men who did not smoke cigarettes regularly only 1 died of lung cancer. This man was a cigar smoker. Expected number of deaths shown in Table 2 are based upon United States mortality data for white males, disregarding smoking habits. We are presently unable to calculate smoking-specific expected rates for this group, since death rates related to smoking are not yet available for the period 1967-71².

We have obtained data in a second, far larger, study of insulation workers. On 1 January 1967 we registered all members of the insulation workers union in the United States and Canada (including New York-New Jersey locals mentioned above)³. There were 17,800 men so enrolled on that day (Table 3). 11,656 completed a questionnaire providing, among other details, information concerning

¹ From the Environmental Cancer Research Project, American Cancer Society and the Mount Sinai School of Medicine of the City University of New York, New York, USA.

² We have reported smoking-specific death rates, 1959-65, in a prospective study of 1,000,000 people (Hammond, 1966). This cohort is now being retraced, and rates for 1966-71 will be available.

³ International Association of Heat and Frost Insulators and Asbestos Workers, AFL-CIO.

Table 1. Members of New York-New Jersey locals of Insulation Workers' Union classified by age as of 1 January 1963, and by years from first occupational exposure to asbestos dust up to 1 January 1963

Age, years	Total no. of members	No. of years since first exposure to asbestos						
		20-24	25-29	30-34	35-39	40-44	45-49	50+
35-39	2	2	—	—	—	—	—	—
40-44	13	12	1	—	—	—	—	—
45-49	32	17	2	13	—	—	—	—
50-54	109	—	1	80	28	—	—	—
55-59	60	—	1	16	34	8	1	—
60-64	42	—	1	3	11	19	8	—
65-69	49	—	—	1	10	18	18	2
70-74	38	—	—	—	3	12	6	17
75-79	21	—	—	—	—	1	5	15
80-84	4	—	—	—	—	1	1	2
Total	370	31	6	113	86	59	39	36

Members classified by age and by smoking habits on or about 1 January 1963

Age, years	Total number	Never smoked regularly	Pipe or cigar only	Ex-cigarette smokers ^a	Current cigarette smokers ^a			
					1-9 per day	10-19 per day	20-39 per day	40+ per day
35-39	2	1	—	1	—	—	—	—
40-44	13	2	—	2	—	—	5	4
45-49	32	2	1	5	—	—	12	12
50-54	109	12	6	26	3	5	33	24
55-59	60	6	5	16	—	3	20	10
60-64	42	7	4	15	1	—	11	4
65-69	49	6	8	17	—	4	9	5
70-74	38	7	7	12	1	4	4	3
75-79	21	3	7	6	—	1	3	1
80-84	4	2	1	1	—	—	—	—
Total	370	48	39	101	5	17	97	63

^a Includes cigarette smokers who also smoked pipes or cigars.Table 2. Expected^a and observed deaths among 370 New York-New Jersey asbestos insulation workers, 1 January 1963-31 December 1971

	Total		No history of cigarette smoking ^b		History of cigarette smoking	
	Number of men, 1 January 1963	Person-years of observation	Expected deaths	Observed deaths	Expected deaths	Observed deaths
		370 2520			87 608	283 1912
Cancer all sites		15.74	94	4.75	15	10.99
Lung cancer		4.87	42	1.26	1	3.31
Pleural mesothelioma		n.a. ^c	5	n.a.	—	n.a.
Peritoneal mesothelioma		n.a.	20	n.a.	7	n.a.
Cancer of stomach		0.94	6	0.30	2	0.84
Cancer of colon, rectum		2.15	6	0.69	2	1.46
Cancer of oesophagus		0.37	—	0.11	—	0.26
Asbestosis		n.a.	21	n.a.	5	n.a.
All other causes		69.22	53	22.28	15	46.94
Total deaths		84.96	168	27.03	35	57.93

^a Expected deaths based upon age-specific US mortality for white males, disregarding smoking habits. Lung cancer estimates based upon US rates for cancer of lung, pleura, bronchus and trachea, categories 162 and 163 of the International Classification of Diseases and Causes of Death, 7th Revision, World Health Organization, Geneva, 1957.^b Includes 38 men who smoked pipe or cigars.^c United States data not available, but these are rare causes of death in the general population.

Table 3. Membership of Asbestos Insulation Workers' Union^a, 1 January 1967, classified by age and by years from first exposure to asbestos dust

Age, years	Total no. of members	Number of years since first exposure to asbestos								
		0-9	10-14	15-19	20-24	25-29	30-34	35-39	40-49	50+
15-19	244	244								
20-24	1695	1695								
25-29	2412	2066	345	1						
30-34	2762	1065	1356	341						
35-39	2987	313	1140	1342	192					
40-44	2260	79	424	1025	591	139	1			
45-49	1589	49	131	433	442	487	47			
50-54	1297	27	88	214	332	377	182	77		
55-59	953	12	49	129	206	176	146	193	72	
60-64	704	1	21	59	131	126	87	100	179	
65-69	417		6	18	40	57	46	28	200	22
70-74	255			6	14	22	21	16	105	71
75-79	111		1		4	8	4	7	37	50
80-84	52					2	1	2	16	31
85+	32							2	8	22
Total	17,800	5551	3581	3569	1952	1394	535	425	617	196

^a Membership in the United States and Canada of the International Association of Heat and Frost Insulators and Asbestos Workers, AFL-CIO

Table 4. Smoking habits of 17,800 Asbestos Insulation Workers in the United States and Canada, on 1 January 1967

Age	Total	No history of cigarette smoking ^a	History of cigarette smoking	Smoking history not known
< 25	1939	281	782	876
25-29	2412	285	1182	945
30-34	2762	314	1435	1013
35-39	2987	309	1640	1038
40-44	2260	223	1395	642
45-49	1589	172	964	453
50-54	1297	134	821	342
55-59	953	201	665	251
60-64	704	122	314	236
65-74	417	25	92	78
75+	195			
Total	17,800	2066	9590	6144

^a Included 609 men who smoked pipes or cigars.

their smoking habits (Table 4). We have followed this cohort through 31 December 1971 (Selikoff *et al.*¹). Although the total group differed from the cohort described above in being, on the average, significantly younger and with shorter duration of exposure, its lung cancer experience has been very much the same.

1,092 deaths occurred during the period 1 January 1967 to 31 December 1971 (see Table 5). Of these, 213 were due to lung cancer; whereas only 44.4 were expected had the experience of these men been the same as that of other US white males of the same age distribution. Among the 9590 men with a history of

regular cigarette smoking, there were 596 deaths, 134 of which were due to lung cancer. Again, we are at this time unable to calculate smoking-specific expected and observed rates because, as noted, death rates related to smoking habits of individuals are unavailable for this period of years.

LUNG CANCER DEATHS AMONG INSULATION WORKERS WHO DO NOT SMOKE CIGARETTES

At the time of our initial report, we had had limited opportunity for studying the incidence of lung cancer among insulation workers with no history of cigarette smoking. There were 87 such men

¹ See p. 209 of this publication.

Table 5. Expected^a and observed deaths among 17,800 US and Canada Asbestos Insulation Workers, 1 January 1967–31 December 1971

		Total		No history of cigarette smoking ^b		History of cigarette smoking		Smoking habits not known	
Number of men, 1 January 1967		17,800		2,066		9,590		6,144	
Person-years of observation		86,300		10,163		46,615		29,522	
		Expected deaths	Observed deaths	Expected deaths	Observed deaths	Expected deaths	Observed deaths	Expected deaths	Observed deaths
Cancer all sites		144.09	459	19.92	33	79.58	265	44.59	161
Lung cancer		44.42	213	5.98	2	25.09	134	13.35	77
Pleural mesothelioma		n.a. ^c	26	n.a.	2	n.a.	17	n.a.	7
Peritoneal mesothelioma		n.a.	51	n.a.	9	n.a.	29	n.a.	13
Cancer of stomach		6.62	16	0.95	1	3.60	8	2.07	7
Cancer of colon, rectum		17.51	26	2.52	4	9.53	14	5.46	8
Cancer of esophagus		3.21	13	0.44	0	1.80	7	0.97	6
Asbestosis		n.a.	78	n.a.	4	n.a.	45	n.a.	29
All other causes		661.54	555	92.67	36	356.67	286	212.20	233
Total deaths		805.63	1092	112.59	73	436.25	596	256.79	423

^a Expected deaths based upon age-specific US mortality rates for white males, disregarding smoking. Lung cancer estimates based upon US rates for cancer of lung, pleura, bronchus and trachea, categories 162 and 163 of the International Classification of Diseases and Causes of Death, 7th Revision, World Health Organization, Geneva, 1967.

^b Included 609 men who smoked pipes or cigars.

^c United States data not available, but these are rare causes of death in the general population.

in our 1963 New York–New Jersey group, and by 1967, only 16 deaths had occurred, none of lung cancer. Only 0.18 lung cancer deaths were expected, however, and with such scant experience we concluded that our information "... does not prove that exposure to asbestos dust has no influence on the risk of lung cancer among non-smokers. However, it does suggest that exposure to asbestos dust does not lead to an extremely high risk of lung cancer among non-smokers." (Selikoff *et al.*, 1968.) Obviously, it was important to obtain further information on the lung cancer risk among non-smoking insulation workers. This is now available, from experience of the cohort described above.

Among the 2066 non-cigarette smokers in the nation-wide study, 73 deaths occurred between 1 January 1967 and 31 December 1971. Two were due to lung cancer. One of these two men was a cigar and pipe smoker, and the other never smoked regularly (Table 5).

It seems clear, then, that lung cancer is uncommon among asbestos insulation workers who have no history of cigarette smoking, and that if the risk is increased such an increase is not great.

PLEURAL MESOTHELIOMA

In our previous report, we were unable to suggest whether or not pleural mesothelioma was related to

cigarette smoking. Only three deaths from this disease occurred in our New York–New Jersey group between 1963 and April 1967. While all three of these men were cigarette smokers, the number was too small for reliable evaluation. Since then two more deaths from pleural mesothelioma have occurred, again among cigarette smokers (Table 2).

In the larger cohort (see Table 5) there were 1092 deaths, of which 26 were due to pleural mesothelioma. Of these 26 men, 17 had a history of regular cigarette smoking, 1 was a pipe smoker, 1 never smoked regularly and 7 were unknown as to smoking habits. We still refrain from drawing definite conclusions because of the small numbers involved.

PERITONEAL MESOTHELIOMA

As with pleural disease, no definitive statement could be made in 1968 concerning the relation of peritoneal mesothelioma to cigarette smoking. Of seven deaths due to peritoneal mesothelioma, two occurred among men with no history of cigarette smoking.

In the large cohort (see Table 5) there were 51 deaths from peritoneal mesothelioma, 9 among the 2066 who did not smoke cigarettes regularly, and 29 among the 9590 cigarette smokers. Thirteen

deaths occurred among 6144 insulation workers for whom smoking histories were not available (Table 5).

These experiences suggest that cigarette smoking does not increase the already high risk of peritoneal mesothelioma among asbestos insulation workers.

The ratio of observed to expected asbestosis deaths was almost three times as high for men with a history of cigarette smoking as for men without a history of cigarette smoking. This was of borderline statistical significance.

ASBESTOSIS

Studies indicate that radiologically-evident pulmonary fibrosis is augmented in asbestos workers by cigarette smoking (Weiss, 1971).

Data now at hand suggest that the risk of death from asbestosis (respiratory insufficiency and cor pulmonale) may be increased by cigarette smoking. These data are reported with the recognition that there must be a mixture of effects of cigarette smoking in such cases, including increased asbestotic fibrosis, and the emphysema, bronchitis and smoking-associated fibrosis related to cigarette smoking in general (Auerbach *et al.*, 1963). These effects could be additive to different degrees, or multiplicative, in specific cases; complex histological and physiological variations are possible.

In the nation-wide study, of the 73 deaths among the 2066 non-smokers, 4 were due to asbestosis, as were 45 of the 596 deaths among the 9590 smokers (Table 5). We computed expected numbers of asbestosis deaths from age-specific death rates for the total study population, disregarding smoking habits.

GASTRO-INTESTINAL CANCER

There seems to be a definite, albeit limited, association between employment in asbestos insulation work and increased risk of death from cancer of the stomach, colon-rectum and oesophagus. Data in this regard were first reported in 1963 (Selikoff *et al.* 1964).

Experiences since 1963 continue to indicate the same conclusion, with increased death rates of approximately the same magnitude. In the large cohort (see Table 5) there were 16 observed *versus* 6.62 expected deaths from cancer of the stomach, 26 observed *versus* 17.51 expected deaths from cancer of the colon-rectum, and 13 observed *versus* 3.21 expected deaths from cancer of the oesophagus. Because of the small numbers of expected and observed deaths from cancer of these sites among the 2066 men with no history of cigarette smoking, we will draw no conclusion concerning the possible interaction of cigarette smoking and asbestos exposure. However, these data are consistent with findings in other studies of a high degree of association between smoking and the occurrence of cancer of the oesophagus.

SUMMARY

We conclude that employment in asbestos insulation work greatly increases the lung cancer risk of cigarette smokers. It is uncertain whether such employment increases the risk of lung cancer among non-smokers. Cigarette smoking may also increase the risk of death from asbestosis, although to a much lesser extent. It is of

interest that the risk of death among non-smoking asbestos insulation workers is greater for asbestosis than for lung cancer. This indicates that even if asbestos workers were to stop cigarette smoking, it would still be necessary to reduce dust exposure below those concentrations associated with the occurrence of asbestosis.

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